



IFWAF12823

In the United States Patent and Trademark Office

In re: Kub et al

Serial No.: 10/022,364 (NC 79,684)

Filed: December 20, 2001

For: Method for Transferring Thin Film Layer Material
To a Flexible Substrate Using a Hydrogen Splitting
Technique

Examiner: Fourson III, George R.
Art Unit: 2823

May 3 , 2004

Appeal Brief

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20230

Sir:

This is an appeal from the final rejection dated Oct. 3, 2003, of claims 1-25. No claims have been allowed.

(1) Real Party in Interest

The real party in interest herein is the United States Government, acting through the Secretary of the Navy.

(2) Related Appeals and Interferences

This application is not involved in any other appeal or interference known to the undersigned.

(4) Status of Claims

All pending claims , i.e., claims 1-25, except claim 17, were finally rejected in the Final Rejection dated Oct. 3, 2003. Although the rejections do not mention claim 17, claim 17 is mentioned in connection with the rejection of claims 10-16, 18, 19 and 21-25 and the Examiner

O I P E / J C W S

MAY - 7 2004

RECEIVED

considers that the Lee reference discloses the use of MgO as a dielectric material in semiconductors and in that sense, claim 17 should be considered part of this rejection.

(4) Status of Amendments

The only amendment filed after the Final Rejection was the amendment entitled “Amendment After Final Rejection” dated March 2, 2004, which was refused entry .

(5) Summary of the Invention

Fig. 1a discloses a basic method of a transferring thin film material to a flexible substrate. The fabrication method begins with a single crystal semiconductor substrate 11, typically inflexible silicon or GaAs. A hydrogen splitting layer 14 is implanted within the substrate and thus the substrate is divided into portions 11a and 11b. An optional stiffening material can be deposited on the substrate, as shown. Substrate 11 is then bonded to a second flexible substrate 16 by means of adhesive layer 18 or by other means. Flexible substrate 16 is typically stainless steel foil, plastic, polyimide, Mylar or another suitable flexible material that has flexibility in excess of silicon. After the bonding step is completed, hydrogen layer splitting is carried out at the splitting layer 14, resulting in the separation of substrate portion 11b from substrate portion 11a. In Fig. 1b, product 10, resulting from the steps of this operation, is ready for fabrication into a flexible substrate device.

Fig. 2a shows an embodiment which is a modification of the method described above. In Fig. 2a, a thin film functional material layer 12 is grown and transferred onto the flexible substrate 16. Because embodiments herein are similar to that of Figs. 1a and Fig. 1b, corresponding elements have been given the same reference numerals. In the embodiment of Fig. 2a, the first substrate 11 is a large diameter growth substrate. Growth substrate materials include

silica, GaAs, quartz, sapphire or another suitable growth substrate material.

A thin film layer functional material 12 is grown on the growth substrate 11 of Fig. 2a. When the growth substrate is silicon, thin film materials, such as SrBaTiO₃ and LiNbO₃, typically will not be grown directly on the silicon growth substrate 11 due to detrimental affects of reactions between the thin film 12 and silicon substrate 11. In such cases, the thin film layer 12 is grown on protective layer 24, which is preferably a platinum or iridium layer. An oxide layer 20 is grown on substrate 11, adhesion layer 22 is deposited on the oxide layer 20 and protective layer 24 is deposited on the adhesion layer 22. The oxide layer 20 insulates the silicon substrate 11 and the adhesion layer facilitates bonding between the oxide layer 20 and the protective layer 24. The implant layer 14 is typically placed within the substrate 11 to prevent damage to the protective layer or the film layer from splitting. The film layer 12 is bonded to the flexible substrate 16 and an optional adhesive layer 18 can be provided between the bonding surfaces to facilitate the bonding process. If desired, the remaining silicon material 11a and up to all of the protective surfaces 20, 22, 24 can be etched away so as to leave only the thin film 12, or the film 12 and the protective layer 24, bonded to the flexible substrate. In Fig. 2b, product 10 is ready for fabrication into a flexible substrate device.

In Fig. 3a, which shows another embodiment of the invention, MgO buffer layer 26 is deposited on growth substrate 11 and the thin film layer is disposed on the MgO buffer layer 26. The MgO buffer layer is a buffer layer instead of protective layer 24, adhesive layer 22 and insulating layer 20. If the MgO layer 26 is sufficiently thick, the hydrogen layer 14 can be implanted within the MgO layer 26 instead of the growth substrate 11. In this embodiment, the implant layer 14 is within the growth substrate 11. As in the other embodiments, the protective

MgO layer 26 can be etched away so as to leave only the thin film functional layer 12 bonded to the flexible substrate 11. Fig. 3b shows product 10 ready for fabrication into a flexible electronic device.

(6) Issues

- (a) Whether claims 1-4, 7 and 9 are anticipated by the Henley reference under 35 USC 102(b);
- (b) Whether claims 5,6 and 8 are obvious over the Henley reference in view of the Kub ('108) reference;
- (c) Whether claims 10-16,18, 19 and 21-25 are obvious over the Henley reference in view of the Lutzen ('169), Kub ('108) and the Lee references;
- (d) Whether claim 20 is obvious over the Henley reference in view of the Lutzen, the Kub and the Lee references.

(7) Grouping of Claims

All claims do not stand or fall together since the standard of patentability is different.

Claims 1-4,7 and 9 are believed to be separately patentable from claims 5,6,8 and 10-25.

(8) Argument

In reference to item (7) Grouping of Claims, above, the claims on appeal do not stand or fall together for the reason that the anticipation and the obviousness rejections have different standards of patentability.

- (i) Claims 5 and 14 were objected to because of the misspelling of the term “steam” in line of each claim. Applicants stand ready and willing to make the correction by rewriting “steam” to “stream.”

(ii) In reference to the rejection of claims 1-4,7 and 9 as being anticipated by the Henley reference, this rejection is untenable for the reason that it does not disclose a flexible substrate. The disclosure in the Henley reference at the top of col. 13 is accidental. The case of Eibel Process Co. v. Minnesota & Ontario Paper Co., 261 U.S. 45 (1923), and its progeny, stand for the proposition that accidental results or disclosure, not intended and not appreciated, do not constitute anticipation.

In the first column on p. 1 herein, it is unequivocally stated that the invention relates to a

“... method for manufacture a functional flexible semiconductor by transferring a single-crystal semiconductor material or thin film material to a flexible substrate.”

At top of col. 1, the Henley reference unequivocally states that its invention is directed to

“... a method and device for cleaving a substrate...”

A comparison of the disclosure herein to the disclosure of the Henley reference leaves no doubt that the disclosures pertain to disparate inventions and that the disclosure of the Henley reference at top of col. 13 is accidental or shot gun.

The anticipation rejection should also be dropped since the Henley reference does not disclose the step of implanting hydrogen ions within a single crystal substrate having a stiffening material with implantation damage prior to implantation, if a stiffening material were provided, as proposed in the Amendment After Final Rejection.

(iii) In connection with the obviousness rejections of claims 5,6 and 8 on the Henley reference in view of the Kub ('108) reference; claims 10-16,18,19 and 21-25 on the Henley reference in view of the Lutzen ('169), the Kub ('108) and the Lee references; and claim 20 on the Henley reference in view of the Lutzen ('169), the Kub ('108), the Lee and the Srikrishnan

references, the Henley reference is directed to cleaving of a substrate whereas here, the invention resides in transferring a functional layer onto a flexible substrate in order to derive the advantages documented herein. As noted at the middle of p.1 of the specification herein, there is interest within the art in cost-effective ways to improve the manufacture of devices having thin film functional materials and thin film single-crystal semiconductor materials bonded on a flexible substrate; a flexible substrate being a material understood to have flexibility in excess of that of silicon. Flexible substrates offer the advantages of low weight, high flexibility and relative strength.

Semiconductor devices with flexible substrates are often made by placing thin film functional materials or single layer semiconductor materials over a suitable flexible substrate. As noted at bottom of p. 1 and top of p. 2 of this specification, the thin film functional materials are typically high temperature superconducting YBCO, ferroelectric, piezoelectric, pyroelectric, high dielectric constant, electro-optic, photoreactive, waveguide, non-linear optical, superconducting, photodetecting, solar cell, semiconductor, wideband gap semiconductor, shaped memory alloy, electrically conducting, or have other desired qualities. As noted at top of p. 2 of this specification, there is much application within the art for single crystal semiconductor materials with flexible substrates. The thin film semiconductor material with flexible substrates can be used for such devices as flexible and low weight transmissive displays, reflective displays, emissive displays, metal tape used for shielding, smart aperture antennae, solar cells, retina prosthesis, MEMs, sensors and actuators, and flexible single-crystal semiconductor optical waveguides.

At about the middle of p. 2 of this specification, it is noted that to obtain a high quality

thin film functional material, the thin layer is typically grown at a growth temperature or annealing temperature of 500-1000°C. The high growth temperature is required to assure a high quality thin film material. However, the highest temperature that a flexible substrate material can withstand is about 150°C. Therefore, it is generally not possible to obtain the best quality thin film material by growing the material directly on a flexible substrate.

The prior art solution was fraught with problems, as noted on p. 2 of this specification, to wit, an optimal solution is to grow the thin film functional material on a first, or growth substrate, such as silicon, that can withstand the increased temperatures and then transfer the thin film material after it is grown to the flexible substrate. However, there have been problems with isolating and then transferring the thin film layer. If the growth substrate is etched away, mechanically lapped forced, or eliminated from the thin film layer in similar fashion, the risk of damage to the thin film layer during this process is considerable. Further, some growth substrate materials are very expensive, and elimination of the substrate to isolate the thin film layer is cost prohibitive. Once the thin film layer is separated from the growth substrate, there is a second problem. The thin film functional layer must have a smooth surface for the transition and bonding to the second substrate to be successful. Otherwise, the bond to the flexible substrate may not hold properly and the device will not function optimally. Also instructive is the disclosure at bottom of p. 2 and top of p. 3 of this specification where it is noted that it is also not possible to grow a thin film layer of a single crystal semiconductor material directly on a flexible substrate. This is because there is no lattice to initiate the single crystal growth. Once again, the ideal solution is to grow a layer of the thin film single crystal material and then transfer it to the flexible substrate. Like the functional material layer, the single crystal semiconductor

material layer must have a smooth surface for the transition and bonding to the flexible substrate to be successful.

As was held in many cases, when prior art references require selective combinations to render obvious a subsequent invention, there must be some reason for the combination other than the hindsight gleaned from the invention itself, see, for instance, Interconnect Planning Corp., 227 U.S.P.Q. at 551. Something in the prior art as a whole must suggest the desirability, and thus, the obviousness, of making the combination, see Lindemann Maschinenfabrik GmbH v. American Hoist and Derick Co., 221 U.S.P.Q. 481, 488. There is no suggestion in the applied prior art to suggest the proposed reference combinations.

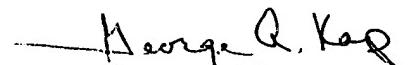
Conclusion

Reversal of the final rejection and allowance of claims 1-25 is requested.

Please charge our account #50-0281 with the appeal fee of \$330.00, or whatever is applicable.

Appellant is amenable to reduction of claims if that is of concern.

Sincerely,


George A. Kap
Reg. No. 22,898
Navy Associate Counsel

(9) Appendix

Claims 1-25, appearing below, are the appealed claims:

1. A method for making a thin film device, said method comprising the steps of:

(a) implanting hydrogen to a selected depth within a single crystal semiconducting

material substrate to form a hydrogen ion layer so as to divide the single crystal substrate into two distinct portions;

(b) bonding the single crystal semiconducting material substrate to a flexible substrate;

and

(c) splitting the single crystal semiconductor substrate along the implanted ion layer and

removing the portion of the substrate, which is on the side of the ion layer away from the flexible substrate, wherein a remaining thin film portion is attached to the flexible substrate.

2. A method according to claim 1, wherein the single crystal semiconductor substrate

further comprises a material selected from a group consisting of silicon, germanium, InP, and GaAs.

3. A method according to claim 1, wherein the flexible substrate comprises a material

selected from a group consisting of stainless steel foil, plastic, polyimide, polyester, and mylar.

4. A method according to claim 1, further comprising the step of :

depositing a stiffening material layer on the surface of the single crystal substrate.

5. A method according to claim 1, further comprising the step of:

directing a high pressure nitrogen gas steam or liquid stream towards the side of the single crystal substrate into which a high dose hydrogen ion implantation has been made to split the single crystal substrate.

6. A method according to claim 1, further comprising the step of:

implanting boron at the same selected depth as the implanted hydrogen for lowering the thermal energy required to split the growth substrate.

7. A method according to claim 1, further comprising the step of:

providing an adhesive layer between the bonding surfaces of the thin film functional layer and the flexible substrate before or during step (b) for improving the bonding thereof.

8. The method according to claim 1, wherein the single crystal semiconductor substrate contain etch stop layers, and wherein the peak of the hydrogen ion implant resides at a depth beyond the etch stop layer.

9. A method according to claim 1, further comprising the step of: smoothing the split silicon surface.

10. A method for making a thin film device, said method comprising the steps of:

(a) depositing at least one protective layer on one surface of a large diameter growth substrate;

(b) growing a film layer of thin film functional material on the at least one protective layer, said functional material comprising a material selected from the group consisting of high temperature superconducting (YBCO), ferroelectric, piezoelectric, pyroelectric, high dielectric constant, electro-optic, photoreactive, waveguide, non-linear optical, superconducting, photodetecting, solar cell, wideband gap, shaped memory alloy, and electrically conducting materials;

(c) implanting hydrogen to a selected depth within the growth substrate or within the at least one protective layer to form a hydrogen ion layer so as to divide the material having the

- growth substrate and the at least one protective layer into distinct portions;
- (d) bonding the growth substrate including the at least one protective layer and the thin film layer to a second flexible substrate; and
- (e) splitting the material having the growth substrate and the at least one protective layer along the implanted ion layer and removing the portion of the material which is on the side of the ion layer away from the flexible substrate.
11. A method according to claim 10, wherein the growth substrate is comprised of a material selected from a group consisting of silicon, GaAs, quartz, and sapphire.
12. A method according to claim 10, wherein the growth substrate comprising silicon.
13. A method according to claim 10, further comprising the step of: depositing a stiffening material layer on the surface of the single crystal substrate.
14. A method according to claim 10, further comprising the step of: directing a high pressure nitrogen gas steam or liquid stream towards the side of the single crystal substrate into which a high dose hydrogen ion implantation has been made to split the single crystal substrate.
15. A method according to claim 10, wherein the growth substrate comprising silicon, wherein the at least one protective layer comprises an oxide layer, an adhesion layer, and a barrier layer; and wherein the method further comprising the steps of; depositing the oxide layer on the silicon substrate; depositing the adhesion layer on the oxide layer; and depositing the barrier layer on the adhesion layer for isolating the thin film layer.
16. A method according to claim 15, wherein the adhesion layer is comprised of titanium, and wherein the barrier layer comprises a material selected from a group consisting of platinum and iridium.

17. A method according to claim 10, the at least one protective layer comprising MgO.

18. A method according to claim 10, wherein the thin film functional material is comprised of a material selected from a group consisting of a single crystal material, a polycrystalline material, and a high temperature sinter ceramic material.

19. A method according to claim 10, wherein the flexible substrate further comprises a material selected from a group consisting of stainless steel foil, plastic, polyimide, polyester, and mylar.

20. A method according to claim 10, further comprising the step of: annealing the thin film functional material layer for strengthening and tempering the thin film layer.

21. A method according to claim 10, further comprising the step of: implanting boron at the same selected depth as the implanted hydrogen for lowering the thermal energy required to split the growth substrate.

22. A method according to claim 10, further comprising the step of: providing an adhesive layer between the bonding surfaces of the thin film functional layer and the flexible substrate before or during step (d) for improving the bonding thereof.

23. A method for making a thin film device, said method comprising the steps of:

(a) growing a film layer of thin film functional material on the surface of a growth substrate, said functional material comprising a material selected from the group consisting of high temperature superconducting (YBCO), ferroelectric, piezoelectric, pyroelectric, high dielectric constant, electro-optic, photoreactive, waveguide, non-linear optical, superconducting, photodetecting, solar cell, wideband gap, shaped memory alloy, and electrically conducting materials;

- (b) implanting hydrogen to a selected depth within the growth substrate to form a hydrogen ion layer so as to divide the growth substrate into distinct portions;
- (c) bonding the growth substrate and associated material having the thin film layer to a second flexible substrate;
- (d) splitting the material having the growth substrate and thin film material along the implanted ion layer and removing the portion of the material which is on the side of the ion layer away from the flexible substrate.

24. A method according to claim 23, further comprising the step of: depositing a stiffening material layer on the surface of the single crystal substrate.

25. A method according to claim 23, further comprising the steps of: directing a high pressure nitrogen gas steam or liquid stream towards the side of the single crystal substrate into which a high dose hydrogen ion implantation has been made to split the single crystal substrate.